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FOREST INSECT INVESTIGATIONS

REPORT OF

BROOD COUNTS FOR 1926

By
M.W. Blackmen,
Specialist in Scolytidae
U.S. Bureau of Entomology

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P.O. Box 3010,
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BROOD COUNTS FOR 1926

Just as in 1925 Brood Counts were made to determine the condition of the brood in mid June and one month later. The early counts in both cases were made by felling trees stripping the entire bark off and preserving and later counting the entire brood. The bark was stripped by quadrants according to the points of the compass and the data for each quadrant kept separately. The later counts in July were made by felling trees and counting the brood in several square feet in each ten foot log of each tree. No record was kept of the stage of the brood nor of the quadrant of the bark from which it was derived. In both cases counts were made of the number of attacks and the number of square feet inside bark was computed so that an accurate balance sheet could be made for each tree.

BROOD COUNTS OF ENTIRE TREES.

During the period of June 12-17, 1925, ten trees typical of different sites and conditions were, felled, the bark removed by quadrants the brood preserved and a careful count made of attack in each quadrant. The data is given in tabulated form in the accompanying table.

BROOD STUDIES - ENTIRE TREES - By Quadrants
Kaibab N.F., June 12-17, 1925

Tree No.	Beetles attacking per sq. ft. North Quad.	East Quad.	South Quad.	West Quad.	Brood per sq. ft. North Quad.	East Quad.	South Quad.	West Quad.	Deficiency or Excess North Quad.	East Quad.	South Quad.	West Quad.	Entire Tree Attacks	Attacking Beetles	Brood	Excess or Deficiency	Entire Tree per sq. ft. attacks	Attacking Beetles	Brood	Excess or deficiency	Exposure Slope	Exposure sun & wind.	Bark Thickness	Bark Char.	Bark dry-ness	Bark light-ness	Crown	Increment last half inch.
K-146	11.3	8.77	10.45	9.68	4.35	6.80	2.15	8.42	-6.95	-1.97	-8.30	-1.30	1146	2292	1237	-1055	5.04	10.09	5.45	-4.54	East	S.E.	1-1/8"	inter-green: med.	butt	M.L.	M.H.	27
K-147	11.57	14.38	13.30	11.40	6.04	5.59	27.46	13.71	-5.53	-1.97	+14.16	+2.67	1308	2616	2207	-409	6.28	12.57	10.61	-1.86	"	S.W.	1¼"	cork	Med.	M.L.	Med.	-
K-148	6.4	6.4	9.6	8.8	6.24	5.36	6.8	10.72	-0.16	-1.04	-2.8	+1.92	195	390	363	-27	3.9	7.8	7.26	-0.54	South	So.	¾"	cork	Med.	M	V.L.	-
K-149	8.48	7.2	7.52	7.68	11.6	3.2	6.32	11.92	+3.12	-4.0	-1.20	+4.24	193	386	413	+27	3.86	7.72	8.26	+0.54	South	S.E.	¾"	"	Med.	M	V.L.	44
K-150	9.54	12.0	9.94	9.0	28.6	32.65	20.88	18.88	+19.06	+20.65	+10.94	+9.86	708	1416	3536	+2120	5.02	10.04	25.07	+15.03	"	So.	2½"	"	M.M.	M.L.	Scrubby Med.	19
K-151	9.52	7.90	7.14	11.43	8.28	6.14	9.19	4.81	-1.24	-1.76	+205	-6.62	378	756	597	-159	4.47	8.94	7.06	-1.88	"		1½"	"	Med.	M.L.	Med.	29
K-152	10.00	10.32	10.36	9.33	6.69	2.51	3.88	6.80	-3.51	-7.81	-6.48	-2.53	1841	3682	1719	-1963	5.97	11.94	4.91	-7.03		Ea.	2"	"	M.M.	M.L.	Scrubby Med.	27
K-153	17.35	13.48	13.48	11.80	0.64	0.64	0.96	0.02	-16.71	-12.74	-12.52	-11.78	870	1740	130	-1610	6.96	13.92	1.04	-12.88	West	E.& S.E.	1"	Scaly: -	-	-	Med.	11
K-154	12.14	13.78	14.28	16.05	0.46	1.75	2.21	1.96	-11.68	-12.03	-12.07	-14.09	789	1578	179	-1399	7.04	14.09	1.59	-12.50	East	S.S.W.	1¼"	Corky:	M.M.	M.L.	Med.	9
K-155	13.31	16.00	14.41	11.50	18.97	9.66	12.57	10.02	+5.66	-6.34	-184	-1.48	1225	2450	2254	-196	7.00	14.00	12.83	-1.17	West	S.W.	2"	"	M.	L.	Med.	10
													8653 Total	17306 Total	13175 Total	-4131					East-3 West-2 South-4							
Averages	11.29 (2)	11.10 (3)	11.44 (1)	10.61 (4)	8.95 (2)	7.27 (4)	9.48 (1)	8.89 (3)	-2.34 (2)	-3.83 (1)	-1.96 (3)	-1.72 (4)	865.3	1730.6	1317.5	-413.1	5.65	11.30	8.65	-2.65			1.41	Corky:	Med.	M.L.	Med.	22

Average-EntireTree - 11.30 8.65 -2.65

A study of this table will bring out several interesting points. As regards number of attacks by quadrants the south section has the highest, North second, East third and West fourth. In number of brood per sq. ft. South first, North second, West third and East fourth. All of the quadrants show a brood deficiency when the ten trees are averaged. This is highest in the East segment, second the the North, third in South, and least in the West. Thus while the West quadrant is lowest both in attack and in brood, it shows the smallest deficiency in brood - i.e. has the largest brood relative to the attack.

Correlation of Brood With Site.

It is also interesting that the South quadrant should not only show the heaviest attack but also the heaviest brood in this mid June examination. This certainly would not be the case a few weeks later. Also the trees on the South slope produced the heaviest brood - an average of 15 per sq. ft. while in the July counts of this year the ~~largest~~ lowest brood in relation to site was found on the South and Southeast slopes, where the brood averaged less than one per sq. ft. This was doubtless due to the drying effects of the sun and wind upon the older larvae and pupae. East and West slopes in June 1926 showed an average brood of 6.62 and 7.90 respectively.

Correlation of Brood with Bark Characteristics.

As regards the bark - this year bark thickness, looseness and moisture seemed to correlate very closely and these characters showed the following correlation with condition of the brood.

Average thickness of bark in 10 trees examined	1.41"
" " " " " 2 " with excess brood	1.61"
" " " " " 8 " " deficient "	1.36"

To my mind this simply means that the thicker bark retained the moisture more efficiently and under the drought conditions of this summer this resulted in a greater survival of the brood in thicker-barked trees.

Correlation of Brood with Intensity of Attack.

Average attack per sq. ft. in the 10 trees examined	5.65
" " " " " " " 2 " with excess brood	4.71
" " " " " " " 8 " " deficient "	5.82

The lower brood in the trees with more numerous attacks was certainly not in this case due to lack of food as there was in all cases a great surplus of uneaten bark. Here again the natural controlling factor was lack of moisture due to a greater drying out of the bark which had suffered the more numerous attacks.

Condition of Brood in Relation to Increment.

Average increment,	last	half	inch	in	8	trees	examined	22.00
"	"	"	"	"	"	2	" with excess brood .	31.50
"	"	"	"	"	"	6	" " deficient "	18.83

Here just as in the souring experiment and in the later brood counts of July, the heavier brood was found in the slower growing trees. This was not expected as we had previously assumed that slower growing trees would dry out sooner than the more rapidly growing ones. However, such was certainly not the case this year.

Plant physiologists tell us that the portions of the sapwood which remains functional in the conveyance of water, after the death of the cambium, are those in the last few growth rings connecting with the needles still on the tree - i.e., if the needles of three years remain on the tree the water carrying tissues of the corresponding rings will be active in the more rapidly growing trees. This would result in a more rapid drying out of the rapidly growing trees - at least in times when the available moisture in the soil is less than normal.

Stage of Brood in Standing Trees June 12-17, 1925.

The accompanying table shows the stage of the brood in the trees felled and examined June 12-17, 1925, expressed in percent of the different stages taken by quadrants and totaled for the entire tree.

STAGES OF BROOD - D. PONDEROSAE - JUNE 12-17, 1925
Kaibab N.F.

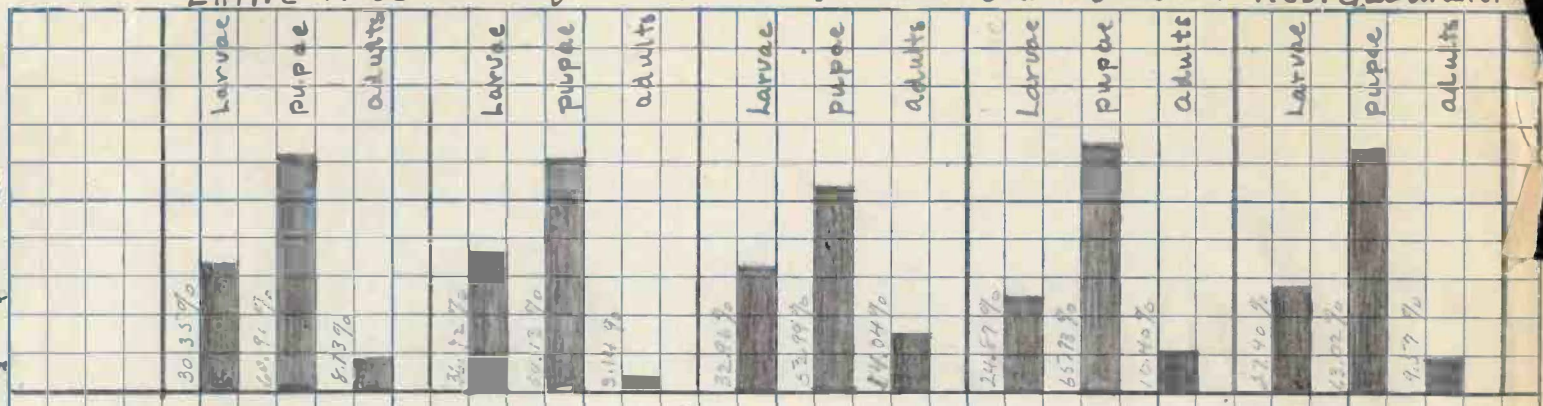
Tree No.	Entire Tree			North Quadrant			East Quadrant			South Quadrant			West Quadrant		
	Larvae	Pupae	Adults	Larvae	Pupae	Adults	Larvae	Pupae	Adults	Larvae	Pupae	Adults	Larvae	Pupae	Adults
K-146	646	573	18	175	73	0	215	173	0	63	60	0	193	267	18
K-147	717	1829	260	173	135	6	131	160	0	259	1080	109	174	454	85
K-148	212	137	14	51	25	1	37	20	10	38	44	3	86	48	0
K-149	213	195	5	73	69	3	17	23	0	49	28	2	74	75	0
K-150	612	2478	446	195	768	38	175	722	246	127	487	117	115	501	45
K-151	271	299	27	62	109	3	64	41	24	81	112	0	64	37	0
K-152	794	805	120	346	208	28	165	52	2	163	141	22	120	404	68
K-153	34	80	16	6	14	0	9	10	0	8	14	8	11	42	8
K-154	96	112	2	10	3	0	23	25	1	30	31	1	33	23	0
K-155	404	1547	439	160	646	29	77	242	106	109	376	68	58	283	100
Totals	3999	8025	1151	1251	2050	108	913	1468	389	907	2373	330	928	2134	324
Grand Totals	13175			3409			2770			3610			3386		
	30.25														
Per cent	60.90		8.73	36.72	60.13	3.14	32.96	52.99	14.04	24.87	65.73	10.40	27.40	63.02	9.57
	60	40		66	34		57	43		57	43		59	41	

Thus as would be expected the North quadrant shows the least advanced brood with the most advanced in the South and East quadrants. Perhaps the best idea of advancement of the brood in per cent can be obtained by dividing the ~~number~~ per Cent of papae in each quadrant and in the entire tree by two and adding half to the per cent of larvae and half to the percent of young adults. Thus we obtain the following figures:

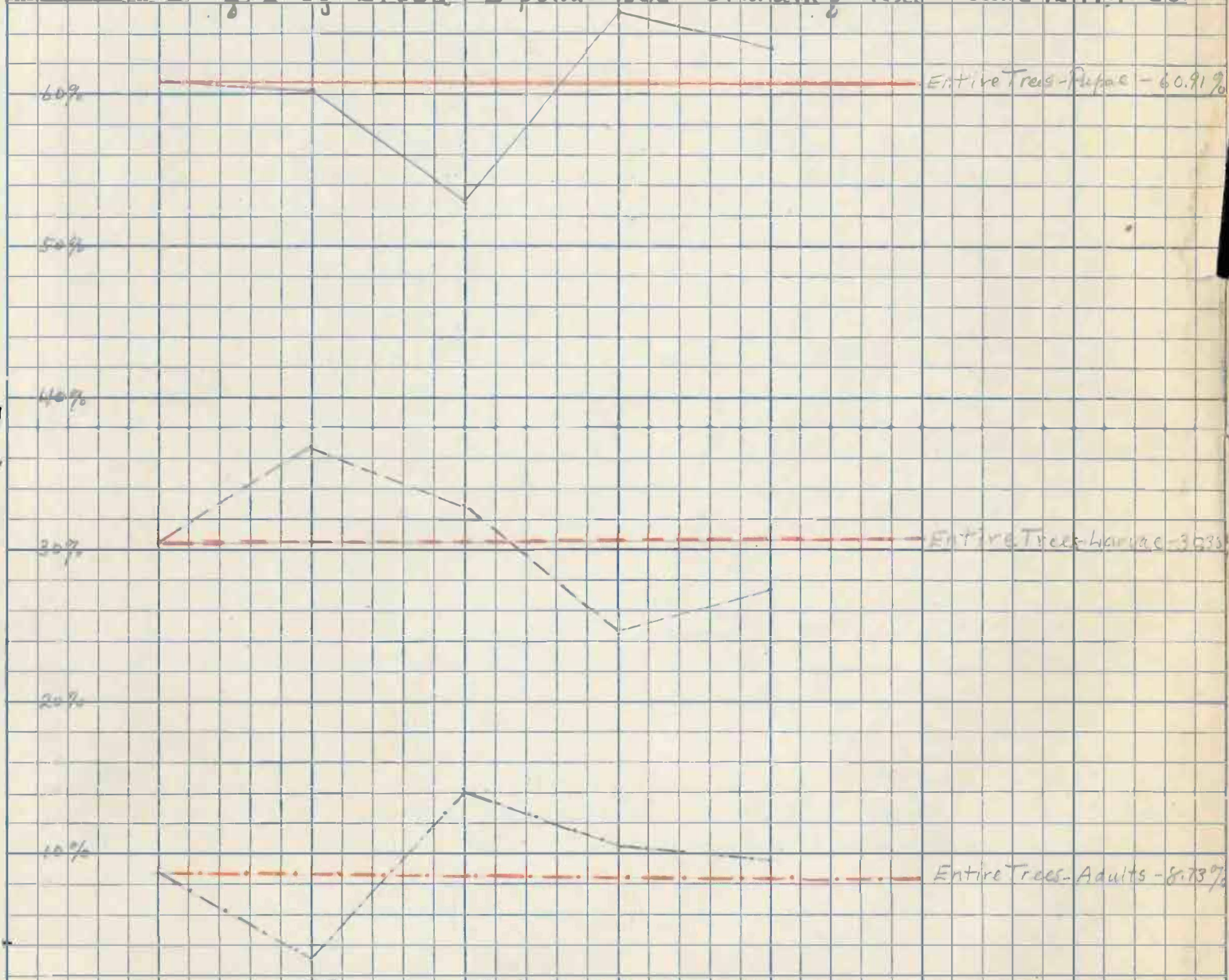
Entire tree	60	40
North quadrant	66	34
East quadrant	57	43
South quadrant	57	43
West quadrant	59	41

The accompanying graphs also show the stages of the brood by quadrants as compared to the averages for the entire tree.

NAME Entire Trees North Quadrant East Quadrant South Quadrant West Quadrant.



Stages of Brood - D. ponderosae - Standing Trees - June 12-17, 1926.



Tree No. Quad East Quad So. Quad West Quad.

Graph Showing Variation of Brood By Quadrants from Averages for Entire Trees (Based on percentages)

BROOD COUNTS OF SAMPLE SQUARE FEET IN STANDING TREES JULY 12-17, 1926

Fifty trees showing various characteristics and in various localities and sites were felled during the week of July 12-17, 1926. Several square feet in each ten-foot log infested was removed and counts made of the brood and attack of D. ponderosae. In all 794 sq. ft. was studied, an average of 15.88 sq. ft. per tree. The detailed data is tabulated on the accompanying chart.

In addition several trees were felled and sampled at Dry Park July 26, but as the other data had already been partly digested and as that obtained at Dry Park was not materially different the latter was not taken into account in the tabulation, but was used merely as a check upon the other. The condition in these Dry Park trees was about the average for trees in the endemic condition elsewhere on the forest. These brood counts are summarized and correlated in the following pages.

Summary

Total sq. ft. examined July 12-17, 1925	794.
Total Brood	1849.
Total Attacks	4371.
Attacking Beetles	8742.
Brood deficiency	6893.
Average Brood per sq. ft.	2.32
" Attack " " "	5.505
Attacking Beetles per sq. ft.	11.01
Brood deficiency " " "	8.69
Brood per cent of attacking beetles	21.15%
Brood Deficiency of attacking "	78.85%

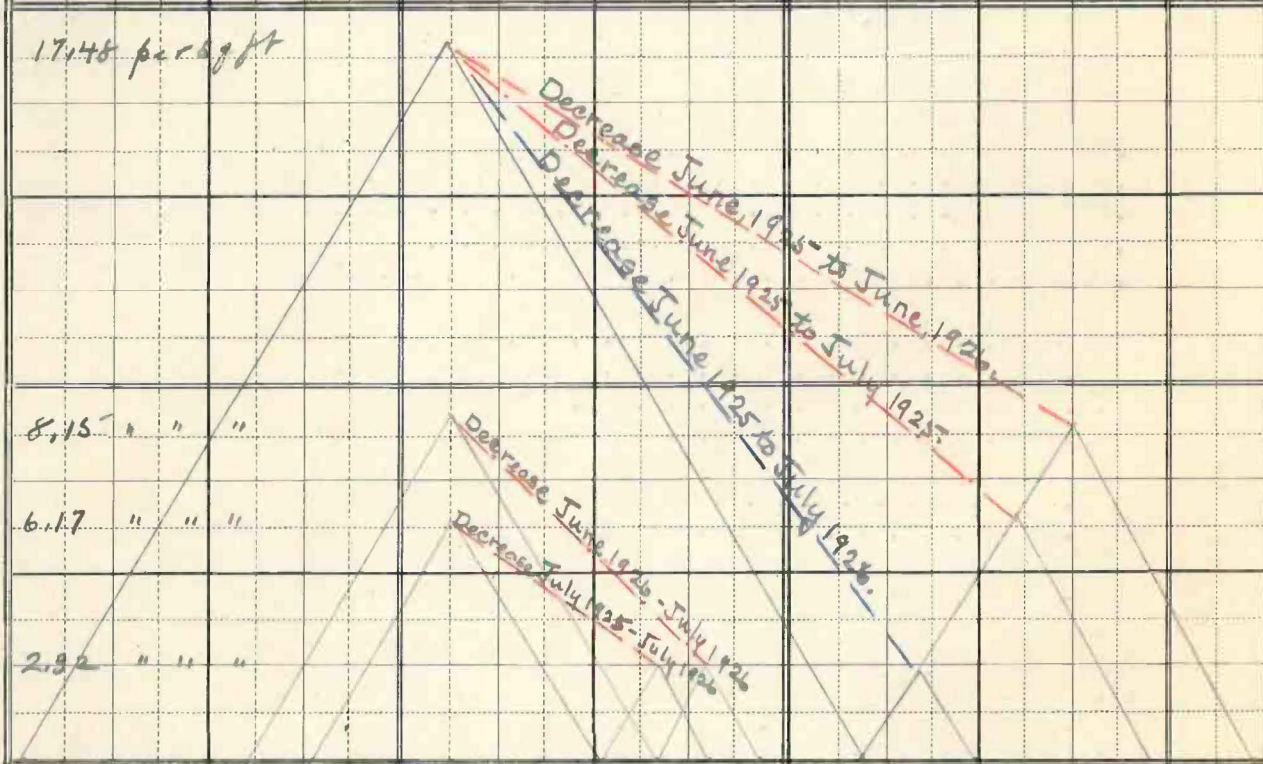
4.7 times as many attacking beetles as brood July 12-17.

The brood in these fifty trees varied from an average per square foot of zero to 10.73; attack varied from 2.9 per square foot to 9.0; and the deficiency of the brood varied from 0.59 to 18.00 per square foot. Not a single tree showed an excess of brood over attacking beetles, and no average of any single series of 10 foot logs showed such an excess, although a few single logs contained brood slightly in excess of attacking beetles of deficiency.

The average brood June 12-17, 1926 was found to be 8.65 per sq foot. On July 12-17, just one month later the brood was 2.32 per sq.ft. Thus the mortality of the brood during this month was 5.98 per sq. ft. or 73.16%. When this data for 1926 is compared with the data taken in 1925 it is seen that the decrease during the period from mid-June to mid-July was greater in 1926 than in 1925. The accompanying graph shows not only this fact but also shows there was a greater decrease in brood per sq. ft. from July, 1925, to July, 1926, than there was between June 1925 and June 1926.

Comparison of Brood of D. ponderosae at Various Dates - 1925 - 1926.

Kaibab N.F.


17.48 per sq ft
8.15 " " "
6.17 " " "
2.92 " " "
Decrease June 1925 - to June 1926.
Decrease June 1925 to July 1925.
Decrease June 1925 to July 1926.
Decrease June 1926 - July 1926
Decrease July 1925 - July 1926

Decrease in Brood per sq. ft.

Decrease	June 1925 - June 1926	--	50.57	per cent.
"	July 1925 - July 1926	--	65.64	" "
"	June 1925 - July 1925	--	64.70	" "
"	June 1926 - July 1926	--	73.16	" "
"	June 1925 - July 1926	--	86.72	" "

Table of Attacks and Brood by 10 Foot Logs

Attacks and Brood by 10 Foot Logs.

First Log					Second Log					Third Log					Fourth Log					Fifth Log					Sixth Log					Entire Tree						
Sq.ft.	Attacks	Brood	Av. Attacks	Av. Brood	Sq.ft.	Attacks	Brood	Av. Attacks	Av. Brood	Sq.ft.	Attacks	Brood	Av. Attacks	Av. Brood	Sq.ft.	Attacks	Brood	Av. Attacks	Av. Brood	Sq.ft.	Attacks	Brood	Av. Attacks	Av. Brood	Sq.ft.	Attacks	Brood	Av. Attacks	Av. Brood	Sq.ft.	Attacks	Brood	Av. Attacks	Av. Brood	Beetles	Average Deficiency	No.
6	24	6	4	1	12	60	82	5	6.83	6	19	20	3.16	3.33	6	22	30	3.66	5.0	2	7	15	3.5	7.5					52	132	183	3.12	4.75	8.24	-3.46	2
4	16	0	4	0	8	48	9	6	1.12	10	50	12	5.0	1.2	4	20	3	5	0.75	4	25	6	6.25	1.5					30	141	30	5.36	1.00	10.72	-9.72	3
5	27	1	5.40	0.20	4.5	31	0	6.8	0	2	16	8	8	4														11.5	74	9	6.43	0.78	12.86	-12.08	4
4	23	1	5.75	0.20	4	26	13	7.0	3.25	4	26	22	6.5	5.5														12.	77	36	6.42	3.0	12.84	-9.84	5
2	11	4	5.5	2.0	6	46	7	7.66	1.17	2	9	8	4.5	1.5														10	46	14	6.66	1.4	13.32	-11.92	6
7	39	13	5.57	1.9	9	70	6	7.77	0.67	4	36	10	9	2.5	2	16	12	8	6									22	161	41	7.52	1.86	16.44	-12.78	7
6	19	0	3.16	0	9	47	7	5.22	.77	11	59	22	6.3	2.0	4	23	0	5.6	0	4	39	1	7.5	0.25	4	15	3	3.25	0.75	36	201	33	8.29	0.87	10.88	9.71	8
6	30	6	5	1	6	44	0	7.33	0	3	26	6	8.66	0														15	100	6	6.66	0.4	13.32	-13.28	9
4	38	4	9.5	1	9	63	23	7.0	2.5	5	31	15	6.2	3	4	35	1	8.75	0.25	4	25	6	6.25	1.5					24	122	49	7.36	1.88	14.74	-12.86	10
4	26	0	6.5	0	6	11	0	1.9	0	2	2	0	1.0	0														12	39	0	3.25	0.0	6.50	-5.50	11
4	13	3	3.25	0.75	6	39	21	6.5	3.5	3	19	13	6.33	5.0														13	71	39	5.54	3.0	11.16	-8.16	12
6	15	15	2.17	2.5	9	38	20	4.2	2.2	8	27	33	5.4	6.6	6	26	22	4.33	3.66	6	34	109	5.66	18	2	12	25	6	12.5	34	150	253	4.41	6.56	8.82	-2.26	13
4	14	8	4	2	6	33	0	5.5	0	2	6	3	3	1.5														12	55	11	4.58	0.91	9.16	-8.25	14
5	31	10	6.2	2	4	24	0	6.0	0																			9	55	10	6.11	1.11	12.22	-11.11	15
8	24	0	3	0	16	89	8	2.8	0.53	10	23	6	3.3	0.6	5	22	9	4.4	1.8	5	22	10	4.4	2.0					45	140	33	3.26	0.77	6.52	-5.75	16
5	41	20	8.2	4	4	40	62	10	15.5	6	20	4	3.33	0.66														16	101	86	6.73	5.73	13.46	-7.73	17
4	26	15	6.50	3.75	6	44	11	7.33	1.8																			16	111	45	6.44	2.81	12.88	10.07	18
4	22	8	5.5	2.0	6	29	4	4.8	0.66	3	19	4	6.33	1.33	2	12	0	6.0	0									15	82	16	5.46	1.06	10.92	9.86	19
4	33	0	8.25	0	4	32	9	8.0	0																			8	65	0	8.12	0	16.24	16.24	20
5	34	19	6.8	3.8	6	46	19	7.66	3.16	2	13	7	6.5	3.5														13	93	45	7.16	3.46	14.32	10.84	21
6	38	10	6.8	1.66	75	43	97	5.7	11.6	5	26	99	5.2	19.8	2	12	14	6	7									206	114	220	5.56	10.73	11.12	.39	22
4	1	0	0.25	0	4	12	16	3.0	4.8	2	16	24	8.0	12.0														10	29	42	2.9	4.2	5.8	1.40	23
4	29	11	7.25	2.75	4	20	6	5	1.5																			8	49	17	6.12	2.12	12.24	10.12	24
4	21	21	5.25	5.25	4	15	3	3.75	0.75																			8	36	24	4.5	3.00	9.00	6.00	25
4	24	3	6.0	0.75	4	20	15	5.0	3.25	3	19	12	6.33	4.0	3	19	23	6.33	7.66									14	82	51	5.85	3.64	11.70	8.06	26
2	14	11	7.0	5.5	2	2.0	0	1.0	0						2	6	6	3	3									4	16	11	4.0	2.75	8.00	5.25	27
12	25	0	2.5	0	8	41	1	5.1	0.12	4	21	5	5.25	1.25	6	47	10	7.8	1.66	6	31	21	5.17	3.5	3	21	27	7.0	9.0	39	186	64	4.77	1.64	9.54	7.90	28
4	10	0	2.5	0	9	51	10	5.66	1.1	6	34	0	5.66	0	3	21	16	7.0	5.33									22	116	26	5.27	1.18	10.54	9.36	29
4	21	2	5.25	0.5	4	19	7	4.75	1.75	2	14	8	7.0	4														10	54	15	5.4	1.58	10.80	9.30	30
10	8	0	8.8	0	10	39	0	3.9	0	6	30	7	5.0	1.2	4	27	0	6.75	0									30	114	7	3.8	0.23	7.60	7.37	31
6	35	28	5.8	4.66	4	23	3	5.75	0.75	2	9	5	4.5	2.5														12	67	36	5.58	3.0	11.16	8.16	32
2	18	0	9.0	0																								2	12	0	9.0	0	18.00	18.00	33
8	0	0	0	0	6	28	0	4.16	0	4	20	3	5.0	0.75	4	21	7	5.25	1.75	2	9	5	4.5	2.5					21	75	15	3.57	0.71	7.14	6.43	34
6	30	26	5.0	4.33	4	22	48	5.5	12	4	25	57	6.25	14.25														14	77	131	5.5	9.35	11.00	1.65	35
6	58	8	9.33	1.33	6	61	1	10.16	0.16	4	24	2	6.0	0.5	3	15	6	5.0	2.0									19	158	17	8.31	8.95	16.62	7.67	36
4	23	4	5.75	1.0	2	11	2	5.5	1.0																			6	34	6	5.67	1.0	11.34	9.34	37
6	32	6	7.5	1.5	8	17	0	8.5	0																			8	47	6	7.83	1.0	15.66	14.66	38
4	29	4	7.25	1.0	4	27	1	6.75	0.25																			8	58	5	7.0	0.62	14.00	13.38	39
4	30	19	7.5	4.75	4	21	6	5.75	1.5	4	24	4	6.0	1.0														12	86	29	7.88	2.25	14.16	11.93	40
4	32	25	8.0	6.25	4	40	9	10.0	2.25																			8	72	34	9.0	4.25	18.00	13.75	41
4	21	4	5.25	1.0	4	25	9	6.5	2.25	3	24	12	8.0	4.0														11	70	25	6.36	2.25	12.72	12.47	42
4	35	4	8.75	1.0	4	24	10	6.0	2.5																			6	59	14	7.37	1.75	14.74	12.99	43
3	18	7	6.0	2.33	2	11	0	5.5	0	2	12	6	6.0	3.0														7	41	13	5.85	1.80	11.70	9.90	44
6	37	7	7.4	1.4	6	35	0	5.8	0	4	27	5	6.75	1.25	3	16	4	6.0	2.0									17	115	16	6.76	0.90	13.52	12.62	45
4	30	12	7.5	3.0	4	26	11	6.25	2.75																			8	555	23	6.88	2.89	13.76	10.87	46
2	18	5	9.0	1.5																								2	18	5	9.0	1.50	18.00	16.50	47
4	25	0	6.25	0	4	33	3	8.25	0.75																			8	58	3	7.25	0.37	14.50	14.13	48
6	28	0	4.16	0	8	36	1	6.33	0.16	4	30	5	7.5	1.25	4	27	5	6.75	1.25									20	130	11	6.50	0.55	13.00	12.45	49
8	34	12	4.25	1.5	10	49	30	4.9	3.0	7	43	32	62	64	10	76	22	7.6	2.2	4	18	8	4.5	2.0					29	240	104	8.16	3.60	12.32	9.72	50
6	18	0	3.0			36	0	6.33	0	2	17	1	8.5	0.5														14	73	1	5.21	0.07	10.42	10.35	51
342	1240	362			288	1550	881			152	876	481			76	478	196			37	281	160			9	46	86			794	4571	1849	5505				Totals
			5.12	1.46				5.38	2.01				5.75	3.16				6.26	2.55				5.97	4.86				5.11	6.11				5.505	2.32	11.01	-8.69	Averages
			-8.76					-8.75					-8.34					-9.97					-7.08					-4.11							

No.	Date: 1926	Locality	Site	Exposure	Stand	Epidemicity	Stump dia.	Circumference in side bark DBH	Circumference in side bark base A	Circumference in side bark top	Infest-ed i. b. area	Height of length	Height of tree	Crown	Increment last 5 in.	Depth of wood	Percent blue-sap-	Bark ing	Bark ness	Bark ure	Bark ure	Bark ness	Cer-am-work	Wood-peck-work
2	7/12	2nd Ridge W.Camp	Flat top of Ridge	Sun on E.&W.	Y.P.	Group of 21	12½	17	50	36	157.5	45'	70	V.L.	30	3.6	5	.75"	C	M	M	2	V.L.
3	"	" "	" "	So.	" "	"	30	29	78	54	27.5	50	69	M.	17	7.5	5	1.5"	C	M	M	15	V.L.
4	"	" "	" "	N.E.	" "	"	14½	14	37	28	93.5	30	64	L.	12	5.5	20	1.0	C	M	M	0	L.
5	"	" "	S ¼ W. Slope	W.	" "	"	17	17	44.5	27	89.7	30	58	M.	13	5.5	5	1.75	C	M	M	0	L.
6	"	" "	" "	"	" "	"	11½	11	39.8	24	67.2	30	64	M.	11	4.5	20	1.0	C	D	T	0	much
7	"	Draw N.W. Camp	Bottom of draw	N.E.	Y.P.,open aspen	2	21	20	56	38	160.	40	63	M.	11	6.0	50	1.75	C	M	M	0	0
8	"	2nd Ridge W.Camp	East	15° East	Y.P., Spruce	6	36	32	104	63	420	60	84	M.	9	10.0	0.0	1.75	C	M	M	0	0
9	"	" "	"	"	Y.P. Spr.fir	6	23½	20	66	39	132	30	60	-	7	8	10	1.25	C	M	M	0	0
10	"	" "	"	"	" " "	32	21½	21	59.6	35	197	50	78	-	7	8.25	5	1.25	C	M	M	0	much
11	7/13	1 mi.N.W. Camp	Top of Flat Ridge	W	Y.P.	3	16½	11	46	36	102.5	30	63	M	11	5.5	95	0.75	I	D	T	2½	0
12	"	" " "	West Slope	10° N.W.	Mixed	7	14½	14	37.69	26	90	30	48	M	42	2.75	10	1.25	S	M	M	0	0
13	"	" " "	" "	N.W.	"	7	21	21	59	28	210	60	76	V.L.	25	5.	10	1.75	C	M	M	27½	0
14	"	" "	North Slope near bottom of draw	S.W.	Y.P.	4	18½	16	42.4	32	93	30	72	M.	10	4.5	10	.83	C	M	T	0	some
15	"	" "	" "	"	Y.P. fir	3	14	13	39	32	60	20	66	M	15	3.75	70	0.75	C	M	T	0	little
16	"	" "	E.Slope Mr.Top	S.E.	" "	single	35	34	101	68	352.5	50	84	M	28	6.5	5	1.37	C	M	L	43½	0
17	"	½ mi. N. camp	E.Slope Mr.bottom	E.	Y.P.& Aspen	group of 4	25	22	628	42	132	30	66	M	7	6.5	30	1.5	C	M	M	7½	0
18	"	" "	E. Slope	E.	" "	"	16	16	415	31	132	40	70	L	17	5.	5	1.37	C	M	M	0	0
19	"	" "	"	"	" "	"	17.6	17.	44.5	32	128	40	75	V.L.	15	3.5	2	1.5	C	M	M	0	V.little
20	"	" "	N.E. Slope	N.E.	Y.P.,Asp.,Spr.fir	group of 2	20	19	56	53	90	20	65	V.M.	16	5.5	95	1.25	C	M	M	0	0
21	7/14	1 mi.W.Murray Lake	E	E. steep.	Y.P.	" " 9	16½	16	44.5	35	-96.9	30	72	M.	7	4.5	2	1.00	S	D	T	0	much
22	"	" "	"	" "	" "	" " "	21	20	58	34	137.2	40	72	L.	16	-	2	1.75	C	M	M	5%	0
23	"	" "	"	" "	" "	" " "	16	15	44	30	92.45	30	72	V.L.	20	3.5	2	1.00	C	Moist	M	0	0
24	"	" "	South Slope	So. gentle	" "	group of 3 in old killing	19	17	46	32	65	20	66	V.M.	15	3	98	2.0	C	M	M	0	0
25	7/15	" "	N.W. Slope	N.W.steep	Mixed	group of 6	16	14	-	35	-	20	65	V.L.	21	4	50	1.13	C	D	T	0	V.little
26	"	" "	" "	" "	"	" " "	16.5	15		25		40	85	L.	20	4.5	20	1.37	C	M	L	5%	0
27	"	" "	" "	" "	"	" " "	10	9	13	16		20	58	L.	45	2.75	95	.75	C	M	M	0	V.little
28	"	" "	N. Slope	Gentle slope near top	Y.P.	" " 2	28	27		26		60	87	V.L.	12	2.50	98	1.85	C	M	L.	54%	V.little
29	"	" "	N. slope	" "	"	" "	23	22		48		40	87	M.	12	6.0	25	1.63	I	M	M	19%	0
30	"	Mr.Main Highway	E. slope	steep	"	"	13½	13		28		36	68	L.	11	2.75	95	1.00	C	D	T	2%	V.little
31	"	2nd Ridge W.Camp	S.E. slope	near top	"	group of 3	34	32		72		40	81	V.M.	27	6.5	0	2.50	C	Moist	L	0	0
32	"	near trap trees	So. "	medium	"	" " 25	16	15		30		30	59	V.L.	35	2.0	2	1.25	C	D	T	6%	0
33	"	" " "	" "	"	"	" "	9.5	9.		22		10	81	M.V.L.	23	-	80	1.12	-	-	-	0	some
34	"	½ mi. N.W.	S.E. slope	gentle	"	" 2	21	20		33		50	90	M.	20	5.5	5	2.0	C	D	T	0	V.little
35	7/16	2nd Ridge West	N.E.	"	"	" " 32	24	23		50		30	81	M.	15	6.	5	1.75	I	D	T	4%	0
36	"	" "	"	"	"	" "	19	18		-		40	63	M.	7	4.5	20	1.5	C	Moist	L	12½	0
37	"	" "	Flat top Ridge	-	Y.P.,Aspen,fir	" "	14	13		28		20	49	M.	5.5	5.5	80	0.75	I	M	T	0	0
38	"	" "	East slope	gentle	Mixed	" " 7	12	12		26		20	68	M.	9	4.0	98	1.0	I	D	T	0	little
39	"	" "	" "	"	"	" "	14	14		28		20	51	L.	7.5	5.0	85	1.0	I	D	T	0	little
40	"	" "	" "	"	"	" "	19	18		37		30	72	M.	15.	6.5	30	1.75	C	D	M	2%	some
41	"	" "	" "	"	"	" "	16	15		37		20	62	M.	5.5	6.0	25	1.25	I	M	M	12½	some
42	"	1½ mi.N.S.W.	West slope	Gentle S.W. near top	Y.P.	Group of 3	17	16		33		30	66	M.	20.	4	80	1.5	C	V.D.	T	0	little
43	"	" "	" "	"	" "	" " "	17½	16		-		20	60	M.	13	5	80	1.25	C	D	M	0	0
44	"	" "	Flat top of Ridge	S.E.	" "	Group of 2	11	10		18		28	51	V.L.	32	2.5	98	0.75	S	D	T	10%	little
45	"	mi.S.E. Camp	W. Slope	Gentle nr. bottom.	" "	" " 5	17	16		32		40	69	M.	12	5.0	20	1.25	C	M	M	0	V.L.
46	"	" "	" "	"	" "	" " "	16½	16		38		20	68	M	12	4.75	65	1.5	C	M	T	0	0
47	7/17	East ridge	Flat top	-	Y.P.	Group of 3	10	9		19		10	30	V.L.	23	2.0	95	1.25	C	D	M	0	0
48	"	" "	" "	"	" "	" " "	14½	14		29		20	59	L.	20	3.5	80	1.75	C	D	M	0	0
49	"	" "	N.E. "	Mr.bot.of draw	Spr.,Aspen	Group of 2	23	22		-		40	72	M.	11	6.5	5	1.5	I	M	M	0	0
50	"	" "	" "	" "	" "	" " "	33	31		Shed 60		50	74	V.M.	6	9.	5	1.75	I	M	M	7%	0
51	"	" "	E. slope	Medium	Mr.top	Y.P.	Group of 20	20	19		56		30	85	M.	8	6.5	2	1.25	I	D	T	0	0
Totals												1645	3469										
Averages								17.8				32.85	69.38%	M		16.32	4.79	36.90	1.35				

It is thus apparent that the high mortality of the brood which began sometime between the attack of the beetles in August, 1924, and the first brood counts in June 1925 has continued at an accelerated rate throughout the two seasons. It is indeed unfortunate that no brood counts or biological data on the Kaibab infestation is available prior to 1925 so that no basis exists for a direct comparison of brood conditions in 1925-26 with brood in previous years when the epidemic was on the increase or holding its own. A comparison of the ecological conditions during a time of brood increase with those existing in 1925 and 26 should come very close to telling us just what factors are most important in the building up and in the control of an epidemic. However, such data is entirely lacking and we can only guess in a general way the number of the brood in these earlier years of the infestation, basing our guess upon the general progress of the infestation as shown by the number of trees killed in the several years. But even here definite figures are lacking prior to the first complete beetle survey of the 1923 trees.

The data upon the infestation prior to the attack of 1923 indicate that during the four year period from 1919 to 1922, inclusive, 128,460,000 board feet was killed - equivalent to about 428,000 trees. The peak of the epidemic was apparently in 1921 and 1922 when the very extensive killings occurred in the Moquitch and Castle areas when from 225,000 to 275,000 trees were killed. The survey of the 1923 infestations showed 82,000 trees killed, apparently a reduction from the previous years. This decrease was doubtless due in part to the mortality of the beetles during their forced migration from the old centers in which they had bred without interruption for several years to new areas which this year (1923) became strongly infested for the first time. If brood counts were available it would be possible to determine rather closely how much of this decrease in 1923 was due to mortality of the beetles incident to their migration to new centers and how much may possibly have been due to earlier mortality of the brood before emergence. Whatever the cause, if the estimates of the killings from 1919-1922 are correct, the data shows unmistakeably that the reduction in the infestation began prior to or at the time of the 1923 flight.

However, the brood in the 1923 trees was apparently healthy and numerous. Of the 82,000 trees infested, 27,780 were barked in the spring of 1924, leaving 54,220 trees from which emergence resulted. Many of the trees left untreated were small and scrubby and were left for that reason. In spite of this the attack of August 1924 resulted in killing 56,000 trees of about average size thus showing that the beetles coming from the 1923 trees were sufficiently numerous to more than maintain the infestation.

Of these 56,000 trees the brood in about 6,000 was destroyed by the control operations and the experimental control of 1925, leaving approximately 50,000 trees undisturbed. The brood from these trees succeeded in killing only about 10% as many trees in the 1925 attack as were killed the previous year. The 1926 killings are negligible and the infestation seems to have returned to the endemic condition over the entire forest.

Thus a brief outline of the history of the infestation would probably be about as follows.- Prior to 1915 the infestation was endemic with occasional single weakened trees dying from the work of the beetle at various places in the forest. Beginning about 1917 or thereabouts, favorable conditions brought about such an increase in the brood that by 1919 the beetles were numerous enough to kill thousands of trees in larger groups in various parts of the forest. This increased in 1920-21 to such an alarming extent that control was undertaken in 1922. By that time groups of hundreds or thousands of trees were being killed in a number of areas as for instance - at Bright Angel Point, Castle Ridge, Moquitch Ridge etc. At Bright Angel the comparatively light infestation was controlled in 1922. In other areas where control was attempted in 1922 and 23 the epidemic was too extensive , the attempts were unsuccessful and the beetles increased rapidly and killed nearly all the available trees. From such areas they were forced to migrate in 1923 and spread in a generally Northern and North-Eastern direction to adjacent and more distant ridges. Many of the beetles were lost in the migration, thus resulting in a decrease in the 1924 infestation. The control work of 1924 was not sufficiently extensive to check the beetles entirely so that the beetles emerging from untreated trees were numerous enough to reinfest more than a corresponding number of new trees. In 1925, however, a combination of natural factors brought about a reduction of about 90 per cent in the epidemic areas and the infestation in all but a few square miles of the forest returned to the endemic condition. In 1926 the reduction continued and the entire remaining infestation is now apparently weakly endemic.

SUMMARIES OF BROOD CONDITIONS BY 10' LOGS

First 10' Log:-

Square feet examined	242.
Total brood	359.
Total Attacks	1240.
Attacking Beetles	2480.
Brood Deficiency	2121.
Brood per sq. ft.	1.48
Attack " " "	5.12
Attacking Beetles per sq. ft.	10.24
Brood Deficiency " " "	8.76

Second 10' Log:-

Square feet examined	288.
Total Brood	581.
Total Attacks	1550.
Attacking Beetles	3100.
Brood Deficiency	2519.
Brood per sq. ft.	2.01
Attack " " "	5.38
Attacking Beetles per sq. ft.	10.76
Deficiency per sq. ft.	8.75

Third 10' Log:-

Square feet examined	152
Total Brood	481
Total Attack	895
Attacking Beetles	1750
Brood Deficiency	1269
Brood per sq. ft.	3.16
Attacks " " "	5.75
Attacking beetles per sq. ft.	11.50
Brood Deficiency " " "	8.34

Fourth 10' Log:-

Square feet examined	76
Total Brood	194
Total Attack	476
Attacking Beetles	958
Brood Deficiency	758
Brood per sq. ft.	2.55
Attacks " " "	6.26
Attacting Beetles per sq. ft.	12.52
Brood Deficiency " " "	9.97

Fifth 10' Log:-

Square feet examined	37
Total Brood	180
Total Attacks	221
Attacking Beetles	442
Brood Deficiency	262

Brood per sq. ft.	4.86
Attack " " "	5.97
Attacking Beetles per sq. ft.	11.94
Deficiency " " "	7.08

Sixth 10' Log:-

Square feet examined	9
Total Brood	55
Total Attacks	46
Attacting Beetles	92
Brood Deficiency	37

Brood per sq. ft.	6.11
Attacks " " "	5.11
Attacking Beetles per sq. ft.	10.22
Brood Deficiency per sq. ft.	4.11

CORRELATION OF BROOD WITH SITE.

Flat Top of Ridge - All Conditions

No. of Trees examined	14
Square feet examined	157
Total Brood	340
Total Attacks	960
Attacking Beetles	1920
Brood Deficiency	1580
Brood per sq. ft.	2.16
Attack per sq. ft.	6.11
Attacking Beetles per sq. ft.	12.22
Brood Deficiency per sq. ft.	10.06

At or Near Bottom of Draw

No. of trees examined	5
Square feet examined	102
Total Brood	177
Total Attacks	641
Attacking Beetles	1282
Brood deficiency	1105
Brood per sq. ft.	1.73
Attacks per sq. ft.	6.28
Attacking Beetles per sq. ft.	12.56
Brood deficiency per sq. ft.	10.73

East Slopes - All Conditions

No. of Trees Examined	17
Square feet examined	276
Total Brood	665
Total Attacks	1614
Attacking Beetles	3228
Brood Deficiency	2563
Brood per sq. ft.	2.41
Attacks per sq. ft.	5.81
Attacking Beetles per sq. ft.	11.62
Brood Deficiency per sq. ft.	9.21

North East Slope - All Conditions

No. of Trees examined	4
Square feet examined	61
Total Brood	159
Total Attacks	430
Attacking Beetles	860
Brood Deficiency	701
Brood per sq. ft.	261
Attacks per sq. ft.	7.05
Attacking Beetles per sq. ft.	14.10
Brood Deficiency per sq. ft.	11.49

North Slope - All Conditions

No. of Trees examined	2
Square Feet examined	61
Total Brood	90
Total Attacks	302
Attacking Beetles	604
Brood Deficiency	514
Brood per sq. ft.	1.47
Attacks per sq. ft.	4.95
Attacking Beetles per sq. ft.	9.90
Brood Deficiency per sq. ft.	8.43

North West Slope - All Conditions

No. of Trees examined	3
Square feet examined	26
Total Brood	86
Total Attacks	134
Attacking Beetles	268
Brood Deficiency	182
Brood per sq. ft.	3.31
Attacks per sq. ft.	5.15
Attacking Beetles per sq. ft.	10.30
Brood Deficiency per sq. ft.	6.99

West Slope - All Conditions

No. of Trees examined	9
Square feet examined	119
Total Brood	374
Total Attacks	671
Attacking Beetles	1342
Brood Deficiency	968
Brood per sq. ft.	3.14
Attacks per sq. ft.	5.63
Attacking Beetles per sq. ft.	11.26
Brood Deficiency per sq. ft.	8.12

South West Slope - All Conditions

No. of Trees Examined	2
Square Feet examined	19
Total Brood	39
Total Attacks	129
Attacking Beetles	258
Brood Deficiency	219
Brood per sq. ft.	2.05
Attacks " " "	6.79
Attacking Beetles per sq. ft.	13.58
Brood Deficiency " " "	11.53

South Slope - All Conditions.

No. of Trees Examined	4
Square Feet Examined	52
Total Brood	60
Total Attacks	248
Attacking Beetles	496
Brood Deficiency	436
Brood per sq. ft.	1.15
Attacks " " "	4.76
Attacking beetles per sq. ft.	9.53
Brood Deficiency per sq. ft.	8.38

South East Slope - All Conditions

No. of Trees Examined	2
Square feet "	64
Total Brood	48
Total attacks	215
Attacking Beetles	430
Brood Deficiency	382
Brood per sq. ft.	0.75
Attacks " " "	3.36
Attacking beetles per sq. ft.	6.71
Brood Deficiency " " "	5.96

In examining the above data the first thing that strikes one is that under no condition of site was a brood found which was even one third as numerous as the attacking beetles. As all sites produced a striking deficiency of brood there is little significance in a comparison of the brood in different sites. Thus the smallest deficiency of brood per sq. ft. was found on a South East slope and this smallest deficiency was associated with the smallest brood found in any site and also with the smallest number of attacks. The highest broods this year were found on North-West and West slopes while last year East slopes produced the highest brood. This difference is easily accounted for in the nearly total absence of the strong South and Southwest winds so characteristic of 1925 which acted as a powerful drying agency in all sites exposed to its action. This year the most powerful drying agency was the sun and in the absence of the cooling effects of the wind the sun was also much more effective in heat kill. Thus the highest mortality from mid-June to mid-July was on south slopes most exposed to sun action.

CORRELATION OF BROOD WITH DEGREE OF EPIDEMICITY.

In taking this year's Brood Counts, a record was kept of the number of trees killed in each group from which individuals were selected for sampling. In summarizing the data later, it was assumed that group killings of three or fewer trees represented endemic conditions and groups of four or more trees represented epidemic conditions. On this basis the data is summarized below.

Brood under Endemic Conditions (Groups of 3 Trees or less)

No. of Trees Examined	18
Square feet examined	319
Total Brood	401
Total Attacks	1670
Attacking Beetles	3340
Brood Deficiency	2939
Brood per sq. ft.	1.25
Attacks per sq. ft.	5.23
Attacking Beetles per sq. ft.	10.46
Brood Deficiency " " "	9.21

Brood under Epidemic Conditions (Groups of more than 3 trees).

No. of Trees Examined	32
Square feet Examined	475
Total Brood	1447
Total Attacks	2799
Attacking Beetles.	5598
Brood Deficiency	4151
Brood per sq. ft.	3.04
Attacks per sq. ft.	5.98
Attacking beetles per sq. ft.	11.78
Brood Deficiency " " "	8.74

It is thus apparent that the attack in epidemic centers are somewhat higher than in endemic centers and that the brood is nearly two and a half times as numerous, thus producing a smaller brood deficiency in the epidemic trees. But there are different degrees of epidemicity in tree epidemic areas and larger and smaller groups are tabulated below.

Brood under Epidemic Conditions - Groups of 4-9 Trees.

No. of Trees Examined	20
Square feet examined	286
Total Brood	965
Total Attacks	1690
Attacking Beetles	3380
Brood Deficiency	2415
Brood per sq. ft.	3.37
Attacks " " "	5.90
Attacking Beetles per sq. ft.	11.80
Brood Deficiency % " "	8.43

Brood under Epidemic Conditions - Groups of 10 Trees.

No. of Trees examined	12
Square Feet examined	188
Total Brood	484
Total Attacks	1119
Attacking Beetles	2238
Brood Deficiency	1754
Brood per sq. ft.	2.57
Attacks per sq. ft.	5.95
Attacking beetles per sq. ft.	11.90
Brood Deficiency " " "	9.33

Thus in the larger epidemic groups there is a slightly higher than average brood (but lower than average for epidemic groups) but also there is a still higher average attack per square foot. This produces a greater average deficiency per square foot than in the average tree and even greater than in the endemic trees. This higher attack is doubtless due to the greater attractive influence of a large group which attracts the late comers to the group. These fill in on trees already occupied up to the optimum, resulting in a too heavy infestation of individual trees which under conditions of this year resulted in a higher mortality of the brood. It should be noted that several of these trees with a lower number of attack produced more than average brood.

SUMMARY OF BROOD CONDITION IN RELATION TO TOTAL HEIGHTH OF TREES INFESTED.

There seems to be a direct correlation between heighth of trees infested and the condition of the contained brood. This may be accidental but such would appear not to be the case when we consider the number of trees involved in each class. However, that may be the figures are given for what they are worth.

Average Heighth of Trees Examined - 69.38'

Brood in Trees Less than Av. Heighth

No. of Trees Examined	28
Square feet "	301.5
Total Brood	515.
Total Attacks	1957.
Attracting Beetles	3964.
Brood Deficiency	3449.
Brood per sq. ft.	1.70
Attacks " " "	6.57
Attacking Beetles per sq. ft.	13.24
Deficiency " " "	11.44

Brood in Trees More than Av. Heighth

No. of Trees Examined	21.
Square feet "	478.5
Total Brood	1282
Total Attacks	2431
Attacking Beetles	4862
Brood Deficiency	3580
Brood per sq. ft.	2.67+
Attacks " " "	5.08
Attacking Beetles per sq. ft.	10.16
Brood Deficiency " " "	7.49

SUMMARY OF BROOD CONDITION IN RELATION TO INFESTED LENGTH OF TREES KILLED.

Although there seems to be nothing of any particular significance brought out by a comparison of trees of shorter and longer infested length in relation to brood, the data is given in the following tabulation.

Average Infested Length of Trees Examined - 32.86'

Brood in Trees of Less than Av. Infested Length.

No. of Trees Examined	31
Square Feet "	296.5
Total Brood	695
Total Attacks	1810
Attacking Beetles	3620
Brood Deficiency	2925
Brood per sq. ft.	2.34
Attacks " " "	6.10
Attacking Beetles per sq. ft.	12.20
Brood Deficiency per sq. ft.	9.86

Brood in Trees of More Than Av. Infested Length

No. of Trees Examined	19
Square feet "	497.5
Total Brood	1154
Total Attacks	2637
Attacking Beetles	5374
Brood Deficiency	4220
Brood per sq. ft.	2.31
Attacks per sq. ft.	5.30
Attacking Beetles per sq. ft.	10.60
Brood Deficiency " " "	8.29

SUMMARY OF BROOD CONDITION IN RELATION TO D.B.H. OF INFESTED TREES.

No significance is attached to the following comparison of brood condition in infested trees of more than average and less than average diameter, as the differences are too small to be of any value:

Average D.B.H. of 50 Trees Examined . . . 17.9"

Brood in Trees below Average D.B.H.

No. of Trees Examined	30.
Square feet Examined	312.
Total Brood	722
Total Attacks	1731
Attacking Beetles	3462
Brood Deficiency	2740
Brood per sq. ft.	2.31
Attacks per sq. ft.	5.54
Attacking beetles per sq. ft.	11.08
Brood deficiency " " "	8.77

Brood in Trees Above Average D.B.H.

No. of Trees Examined	20
Square Feet Examined	481
Total Brood	1126
Total Attacks	2639
Attacking Beetles	5278
Brood Deficiency	4152
Brood per sq. ft.	2.34
Attacks per sq. ft.	5.48
Attacking Beetles per sq. ft.	10.96
Brood Deficiency " " "	8.62

SUMMARY OF BROOD CONDITION IN RELATION TO CHARACTER OF CROWN.

The character of the crown in the 50 trees studied is distributed as follows:

Very heavy	5
Heavy	12
Medium	13
Light	9
Very light	9
No record	2

The mean condition is therefore "medium" with 17 trees having heavier and 18 trees lighter crowns. The following tabulations will serve as a basis of comparison of the three conditions:

Brood in Trees with Medium Crown.

No. of Trees Examined	13
Square Feet Examined	179
Total Brood	379
Total Attacks	974
Attacking Beetles	1948
Brood Deficiency	1569
Brood per sq. ft.	2.12
Attacks per sq. ft.	7.44
Attacking Beetles per sq.ft.	14.87
Brood Deficiency " " "	12.75

Brood in Trees With Light Crown

No. of Trees Examined	18.
Square Feet "	226.
Total Brood	869.
Total Attacks	1179
Attacking Beetles	2358
Brood Deficiency	1489
Brood per sq. ft.	3.84 +
Attacks " " "	5.21 +
Attacking Beetles per sq. ft.	10.42 +
Brood Deficiency " " "	6.58

Brood in Trees with Heavier Crown

No. of Trees Examined	17
Square Feet	347
Total Brood	545
Total Attacks	1907
Attacking Beetles	3814
Brood Deficiency	3269

Brood per sq. ft.	1.57
Attacks " " "	5.49+
Attacking Beetles per sq.ft.	10.98
Brood Deficiency " " "	9.41

It is thus seen that trees with "medium" Crown possessed a brood of 2.12 which is fairly near the average brood for all trees. Those having a lighter than average crown had a brood of 3.84 per sq. ft. and those having a heavier crown had only 1.57 per sq. ft. Thus the correlation of heavier crown with lower brood is similar to that of more rapid growth and wider sapwood.

SUMMARY OF BROOD CONDITION IN RELATION TO RADIAL INCREMENT OF LAST HALF INCH.

The increment of the last half inch radius was in all cases taken on the north side of the stump at a heighth of 14-20 inches from the ground. The average increment for the 50 trees studied was 16.32. The folowing tabulation shows that the brood in the more rapidly growing trees was over 20 per cent lower than in the slower growing trees, and the broods deficiency about 30% higher in spite of the fact that the more rapidly growing trees suffered a much higher attack.

Brood in Trees With More Rapid Increment (Rapid Growing Trees)

No. of Trees Examined	33.
Square Feet Examined	508.
Total Brood	1020.
Total Attacks	3151
Attacking Beetles	6302
Brood Deficiency	5282

Brood per sq. ft.	2.01
Attacks " " "	6.20
Attacking Beetles per sq. ft.	12.40
Brood Deficiency " " "	10.39

Brood in Trees With Slower Increment (Slow Growing Trees)

No. of Trees Examined	17.
Square feet "	286.
Total Brood	728
Total Attacks	1319
Attacking Beetles	2638
Brood Deficiency	1910

Brood per sq. ft.	2.54
Attacks " " "	4.61
Attacking Beetles per sq.ft.	9.22
Brood Deficiency " " "	6.68

SUMMARY OF BROOD CONDITION IN RELATION TO DEPTH OF SAPWOOD.

The width of sapwood here used was the estimated average width on the stump. The average depth of sapwood was found to be 4.79" The following tabulations show that the wider sapwood is correlated with a smaller average brood a higher brood deficiency and a slightly higher attack.

Brood in Trees With Narrower Sapwood

No. of Trees Examined	23
Square Feet "	304
Total Brood	861
Total Attacks	1680
Attacking Beetles	3360
Brood Deficiency	2499

Brood per sq. ft.	2.83
Attacks " " "	5.52
Attacking Beetles per sq.ft.	11.04
Brood Deficiency " " "	8.21

Brood in Trees with Wider Sapwood .

No. of Trees Examined	25
Square Feet "	467
Total Brood	767
Total Attacks	2668
Attacking Beetles	5336
Brood Deficiency	4569

Brood per sq. ft.	1.64
Attacks " " "	5.71
Attacking Beetles per sq. ft.	11.42
Brood Deficiency " " "	9.78

SUMMARY OF BROOD CONDITION IN RELATION TO DEGREE OF BLUEING OF SAPWOOD.

There has been considerable discussion among us as to the significance of the "blueing fungus" in relation to the brood. I have always held that the degree of blueing was merely incidental to the progressive drying out of successive layers of the sapwood - the fungus extending farther and farther into the wood as the wood gradually dried out and successively deeper layers of woody tissue come to possess the optimum amount of moisture and oxygen contents required by the fungus. Thus as condition exist in the yellow pine on the Kaibab the chief significance of the amount of blueing is that it serves as an excellent indicator of the degree to which the sapwood has lost its originally large water content.

That was the conclusion I deduced last year and the observations this year all seem to bear out the earlier judgement. In the following tabulations the greater percent of blueing (i.e. the greater degree of dryness of the sapwood) is correlated with a smaller brood, a slightly larger attack and a considerably higher deficiency.

Average per cent of Blueing - 36.80%

Brood in Trees With Less than 37% Blueing

No. of Trees Examined	31
Square feet "	608
Total Brood	1568
Total Attacks	3353
Attacking Beetles	6706
Brood Deficiency	5138

Brood per sq. ft.	2.58
Attacks " " "	5.51
Attacking Beetles per sq. ft.	11.02
Brood Deficiency " " "	8.44

Brood in Trees with more than 37% Blueing

No. of Trees Examined	19
Square Feet "	186
Total Brood	280
Total Attacks	1113
Attacking Beetles	2226
Brood Deficiency	1946

Brood per sq. ft.	1.51
Attacks " " "	5.93
Attacking Beetles per sq.ft.	11.86
Brood Deficiency " " "	10.35

SUMMARY OF BROOD CONDITION IN RELATION TO THICKNESS OF BARK.

The average thickness of the bark as computed from measurements of the bark thickness on the stump was 1.35". There seems to be a distinct correlation between thicker bark and a heavier brood, lighter attack and smaller brood deficiency. The real factors involved here are doubtless the greater protection of the thicker bark both against drying out of the inner bark and against sun or heat kill off the brood.

Brood in Trees with Thinner Bark

No. of Trees Examined	24
Square feet examined	269
Total Brood	546
Total Attacks	1607
Attacking Beetles	3214
Brood Deficiency	2668

Brood per sq. ft.	2.03
Attacks " " "	5.97
Attacking Beetles per Sq. Ft.	11.94
Brood Deficiency " " "	9.91

Brood in Trees with Thicker Bark

No. of Trees Examined	26
Square feet "	524
Total Brood	1512
Total Attacks	2863
Attacking Beetles	5726
Brood Deficiency	4414

Brood per sq. ft.	2.50+
Attacks " " "	5.46
Attacking Beetles per sq. ft.	10.92
Brood Deficiency " " "	8.42

SUMMARY OF BROOD CONDITION IN RELATION TO NUMBER OF ATTACKS PER SQUARE FOOT.

The average number of attacks when computed on the basis of total attacks divided by total infested area is 5.505 per square foot. In this connection, however, the average attack was computed and averaged by trees giving an average attack of 5.98 per sq. ft. The following table shows that in trees showing more than the average attack per sq. ft. the brood is considerably lighter and the brood deficiency nearly twice as great. The reason for this higher mortality of the brood has been discussed in connection with similar findings in the brood counts in entire trees.

Average Attacks per sq. ft. - Taken by Trees = 5.98

Brood in Trees with fewer than Average Attacks

No. of Trees Examined	23
Square Feet "	453
Total Brood	1187
Total Attacks	1904
Attacking Beetles	3808
Brood Deficiency	2621

Brood per sq. ft.	2.62
Attacks " " "	4.18
Attacking Beetles per sq. ft.	8.36
Brood Deficiency	5.74

Brood in Trees with more than Average Attacks

No. of Trees Examined	27
Square Feet "	340
Total Brood	654
Total Attacks	2256
Attacking Beetles	4512
Brood Deficiency	3858

Brood per sq. ft.	1.92
Attacks " " "	6.63
Attacking Beetles per sq. ft.	13.26
Brood Deficiency " " "	11.34

FACTORS RESPONSIBLE FOR MORTALITY OF BROOD IN 1925 AND 1926.

During the summer of 1926 the same factors were operative in reducing the brood of infested trees as in 1925 but apparently were effective in differing degrees. In 1925 the three most important factors were (1) the drying out of the bark; (2) the larvae of Cerambycids and (3) woodpeckers.

The drying out of the bark was due to a combination of circumstances - an apparent deficient snowfall during the winter of 1924-25, a deficient rainfall during the summer of 1925, the drying effect of sun and wind upon the standing infested trees and upon the soil. One of the most important factors in drying was the nearly daily heavy winds from the south and southwest. These winds by keeping a constant current of air in motion over the tree trunks apparently acted as a deterrent to sun-kill, but in standing trees the increased drying of the bark due to this current of air was apparently about as effective in bringing about conditions destructive to the brood.

The moisture conditions both in the soil and in the tree appeared to be more favorable in early June 1926 - apparently due to a heavier snowfall during the preceeding winter. Yet in spite of this the brood in June 1926 was not quite half as numerous as one year earlier. The significance of this is discussed in another place. This smaller brood also suffered a greater percentage of reduction during the month June 17 to July 17 than did the brood in 1925 in a similar period of time - the reduction in 1925 being 64.7% as compared with 73.16% in 1926. Most of this greater reduction is ascribed to weather conditions. Heat-kill due to direct sunlight was more marked than in 1925 because of the comparative absence of wind. Drying was also more complete and effective in spite of the moister conditions in early June, because from June to August 6 there were only three very light showers - only one of which was sufficient to "lay the dust". Thus the conditions in the trees were excessively dry by the latter part of July and the brood was so reduced that it was nearly impossible to find beetles for experimental purposes.

The general drought on the Kaibab is shown by the drying of most of the water holes to such an extent that the stock suffered from lack of water and by the condition of the range which was excessively dry and bare all over the mountain by the middle of July.

The other factors believed to be important last year - namely, cerambycid larvae, and woodpeckers - were relatively less efficient this year. The Cerambycids seemed to have suffered a depletion in numbers about proportional to the decrease in the Dendroctonus infestation. A similar reduction in numbers was also noted with regard to Ips and other secondary bark beetles and also in the large clerid Enoclerus sphegeus. Woodpeckers were present as before but had transferred their main activities to the larvae of Rhagium and other beetles found in trees killed in 1924. Several half days were spent in trying to find and shoot woodpeckers actually at work upon 1925 infested trees. Only four specimens were killed and an examination of the stomach contents showed that not a single one of them had recently eaten any stage of Dendroctonus although their stomachs were well filled with the larvae of Rhagium and other cerambycids. The stomach of one woodpecker was completely filled with large black carpenter ants. Another stomach contained 9 large cerambycid larvae, one pronotum and one elytron of Pityogenes carinulatus and a quantity of fragments of bark and wood. The woodpeckers apparently seek food where it is most abundant and most easily obtained. Dendroctonus brood was neither abundant nor easy to find this year and did not form any appreciable part of the bird's food.

The writer is of the opinion that the greater reduction in brood this year was due in no small degree to what might be described as the cumulative effect of continued adverse conditions. By this I mean that the adverse conditions extending over several seasons not only was responsible for the actual death of a large proportion of the brood, but in addition had a weakening effect upon those which did manage to survive in spite of the very unfavorable environment. Thus these survivors during the first few years of unfavorable conditions would become progressively weaker and less able to resist the adverse factors resulting in the course of time in a very rapid selection of a very few individuals representing the strongest strain of the race. It is the progeny of these few rigidly selected survivors which is able to increase so surprisingly when conditions again become favorable for the species.

Parallel cases to this are not difficult to find in human history. For instance - it is known that a large per cent of the early cononists of Australia and other English settlements were taken largely from the slums of the larger British cities such as London and Edinburg. These men were for the most undersized and diseased due to generations of living under very unfavorable and unsanitary conditions. Yet while diseased and apparently weak physically they were more than usually resistant due to the survival of only the stronger through many generations. When placed under favorable conditions they gave rise to one of the most hardy strains of the British people.

That something of the same sort is going on in the brood of the Black Hills Beetle on the Kaibab is indicated by the very noticeable decrease in size of many of the adults of the 1926 generation as compared to those of 1925. Thus there is not only a very apparent decrease in the number of brood but an equally remarkable but of course less apparent decrease in the size of the survivors.